

## CLAIMS

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1. A multi-carrier transmission system having a first and a second transceiver, each of said transceivers having a receiver and a transmitter, wherein data is transmitted between said transceivers by modulating said data onto a multiplicity of carrier waves in the form of multi-bit symbols, wherein each carrier wave constitutes a channel, and wherein the number of bits per symbol, (the bit loading), varies between channels and, within a channel, with time, so that each channel has associated therewith a bit loading parameter, characterised in that, in operation, said multi-carrier system is adapted to synchronously update, at said first and second transceivers, the bit loading parameters associated with each channel by transmission of data over a control channel, in that said control channel is established, at system start-up, on a predetermined one of said multiplicity of carrier waves whose identity is known to said first and second transceivers, and in that said control channel is, after start-up, changed from said predetermined channel to a further channel, selected by said first transceiver on the basis of channel characteristics.

2. A multi-carrier transmission system, as claimed in claim 1, characterised in that decisions relating to changes in bit loading and control channel selection are initiated by said first transceiver transmitting command signals over said control channel, in that said second transceiver effects changes in bit loading and control channel carrier wave selection, and in that said second transceiver measures changes in channel characteristics and forwards data relating thereto over said control channel to said first transceiver.

3. A multi-carrier transmission system, as claimed in claim 1, ~~or 2~~, characterised in that said multi-carrier transmission system is a DMT transmission system.

5 4. A multi-carrier transmission system, as claimed in either claim 1, ~~or 2~~, characterised in that said multi-carrier transmission system is a DMT based VDSL system.

5 a 5. A multi-carrier transmission system, as claimed in either claim 1, ~~or 2~~, characterised in that said multi-carrier transmission system is a DMT based ADSL system.

10 6. <sup>Claim 3</sup> A multi-carrier transmission system, as claimed in ~~any of claims 3 to 5~~, characterised in that said predetermined carrier wave is selected from said multiplicity of carrier waves on the basis of channel SNR characteristics so that said control channel is subject to minimal interference from noise.

15 7. <sup>Claim 1</sup> A multi-carrier transmission system, as claimed in ~~any previous claim~~, characterised in that, on activation of said multi-carrier system, said control channel is established by means of a process comprising the following three steps:

- establishment of said control channel on a predetermined carrier wave;
- transfer of said control channel to a carrier wave selected by said multi-carrier system and enabling bit loading control; and
- enabling of all carrier waves.

25 8. A multi-carrier transmission system, as claimed in claim 7, characterised in that said step of establishing said control channel includes, in each of said first and

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second transceivers:

- booting said transmitter;
- said transmitter continuously transmitting frames in which all carrier waves other than said predetermined wave are modulated with random data;
- said transmitter transmitting a system heartbeat;
- booting said receiver;
- said receiver initiating channel equalization;
- synchronizing clocks in said first and second transceivers; and
- establishing said control channel on said predetermined carrier wave on receipt of a heartbeat.

9. A multi-carrier system, as claimed in claim 7, ~~or~~ ~~8~~, characterised in that said step of transferring said control channel includes, in said first transceiver:

- reception of data, by the transmitter, relating to measured channel characteristics from receivers in both said first and second transceivers;
- selection of a carrier wave to which said control channel is to be reallocated by said transmitter;
- transmission, by said transmitter, of a signal

identifying said carrier wave, to which said control channel is to be reallocated, to said second transceiver;

- on receipt of a confirmation signal, from said second transceiver, said transmitter terminating said control channel on said predetermined carrier wave;
- said transmitter starting said control channel on the reallocated carrier wave at a heartbeat;
- said receiver measuring channel characteristics and transmitting data relating thereto to said transmitter in said first transceiver;
- said receiver equalizing said measured channel;
- said receiver obtaining a channel estimation from the second transceiver and transmitting data relating thereto to said transmitter in said first transceiver;
- said receiver receiving data identifying the carrier wave for reallocation of said control channel;
- said receiver receiving a confirmation signal from said second transceiver;
- said receiver terminating the control channel on said predetermined carrier wave;
- said receiver establishing the control channel

on the reallocated carrier wave; and

- if said control channel cannot be established, returning to said step, according to claim 8, of establishing said control channel.

5 *aa*  
10. A multi-carrier system as claimed in <sup>Claim 7</sup> ~~any of claims~~  
~~7 to 9~~, characterised in that said step of enabling all  
carrier waves includes, on a continuous basis, in said  
first transceiver:

- said transmitter obtaining data relating to measured channels from receivers in both said transceivers;
- said transmitter determining the bit loading parameter for each carrier wave;
- said transmitter transmitting data relating to the bit loading parameter to said second transceiver;
- said transmitter changing the bit loading parameter on confirmation from said second transceiver;
- the receiver measuring the channel characteristics of said multiplicity of channels and sending data relating to said measurements to said transmitter;
- the receiver equalizing said multiplicity of channels in accordance with said measured channel characteristics;
- the receiver obtaining a channel estimation from said second transceiver for each of said

multiplicity of channels;

- the receiver obtaining a new bit loading parameter for each of said multiplicity of channels;
- 5        - the receiver obtaining a confirmation signal from said second transceiver;
- the receiver updating the bit loading parameters for each of the multiplicity of channels.

10       11. A multi-carrier transmission system, as claimed in  
      <sup>Claim 1</sup>  
      ~~any previous claim~~, characterised in that channel  
      characteristics are estimated by periodic transmission,  
      by one of said transceivers, of a base sync frame having  
      a predetermined content and comparing, in the other of  
15       said transceivers, the received sync frame with a  
      reference frame.

20       12. A multi-carrier transmission system, as claimed in  
      claim 11, characterised in that said channel  
      characteristics include attenuation, phase shifting and  
      variance.

25       13. <sup>Claim 1</sup> A multi-carrier transmission system, as claimed in  
      ~~either claim 11, or 12~~, characterised in that said base  
      sync frames are transmitted at intervals, the BSI, and  
      said BSI is locked into said transceivers thereby  
      enabling said transceivers to identify a frame as a sync  
      frame.

30       14. A multi-carrier transmission system, as claimed in  
      claim 13, characterised in that additional sync frames  
      are transmitted at intervals between said base sync  
      frames.

15. A multi-carrier transmission system, as claimed in ~~either of claims 13, or 14~~, characterised in that said first transceiver issues commands for system reconfiguration at the start of a BSI, and in that system reconfiguration is effected at the start of the next BSI.

16. A multi-carrier transmission system, as claimed in ~~any of claims 13 to 15~~, characterised in that said BSI is greater than twice the system transit time for signals.

17. In a multi-carrier transmission system having a first and a second transceiver, each of said transceivers having a receiver and a transmitter, wherein data is transmitted between said transceivers by modulating said data onto a multiplicity of carrier waves in the form of multi-bit symbols, wherein each of said carrier waves constitutes a channel, and wherein the number of bits per symbol, (the bit loading), varies between channels and, within a channel, with time, so that each channel has associated therewith a bit loading parameter, a method of operating a control channel characterised by:

- synchronously updating, at said first and second transceivers, the bit loading parameters associated with each channel by transmission of data over the control channel;
- establishing said control channel, at system start-up, on a predetermined one of said multiplicity of carrier waves whose identity is known to said first and second transceivers; and
- after start-up, changing said control channel

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from said predetermined channel to a further channel, selected by said first transceiver on the basis of channel characteristics such as SNR.

5 18. A method, as claimed in claim 17, characterised by:

- initiating decisions, relating to changes in bit loading and control channel selection, in said first transceiver and transmitting command signals over said control channel;
- 10 - said second transceiver effecting changes in bit loading and control channel carrier wave selection; and
- said second transceiver measuring changes in channel characteristics and forwarding data relating thereto over said control channel to  
15 said first transceiver.

*a* 19. A method, as claimed in claim 17, ~~or 18~~, characterised in that said multi-carrier transmission system is a DMT transmission system.

*a* 20. A method, as claimed in either claim 17, ~~or 18~~, characterised in that said multi-carrier transmission system is a DMT based VDSL system.

*a* 21. A method, as claimed in either claim 17, ~~or 18~~, characterised in that said multi-carrier transmission system is a DMT based ADSL system.  
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*a* 22. A method, as claimed in <sup>claim 19</sup> ~~any of claims 19 to 21~~, characterised by selecting said predetermined carrier wave from said multiplicity of carrier waves on the basis of channel SNR characteristics so that said



control channel is subject to minimal interference from noise.

*Claim 17*  
23 A method, as claimed in ~~any of claims 17 to 22,~~  
characterised by establishing said control channel, on  
activation of said multi-carrier system, by means of a  
process comprising the following three steps:

- establishing said control channel on a predetermined carrier wave;
- transferring said control channel to a carrier wave selected by said multi-carrier system and enabling bit loading control; and
- enabling all carrier waves.

24. A method, as claimed in claim 23, characterised by said step of establishing said control channel including, in each of said first and second transceivers:

- booting said transmitter;
- said transmitter continuously transmitting frames in which all carrier waves other than said predetermined wave are modulated with random data;
- said transmitter transmitting a system heartbeat;
- booting said receiver;
- said receiver initiating channel equalization;
- synchronizing clocks in said first and second

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transceivers; and

- establishing said control channel on said predetermined carrier wave on receipt of a heartbeat.

5 *n* 25. A method, as claimed in claim 23, ~~or 24~~, characterised by said step of transferring said control channel including, in said first transceiver:

- reception of data, by the transmitter, relating to measured channel characteristics from receivers in both said first and second transceivers;
- selection of a carrier wave to which said control channel is to be reallocated by said transmitter;
- 15 - transmission, by said transmitter, of a signal identifying said carrier wave, to which said control channel is to be reallocated, to said second transceiver;
- on receipt of a confirmation signal, from said second transceiver, said transmitter terminating said control channel on said predetermined carrier wave;
- said transmitter starting said control channel on the reallocated carrier wave at a heartbeat;
- 25 - said receiver measuring channel characteristics and transmitting data relating thereto to said transmitter in said first transceiver;

- said receiver equalizing said measured channel;
- said receiver obtaining a channel estimation from the second transceiver and transmitting data relating thereto to said transmitter in said first transceiver;
- said receiver receiving data identifying the carrier wave for reallocation of said control channel;
- said receiver receiving a confirmation signal from said second transceiver;
- said receiver terminating the control channel on said predetermined carrier wave;
- said receiver establishing the control channel on the reallocated carrier wave; and
- if said control channel cannot be established, returning to said step, according to claim 25, of establishing said control channel.

26. A method, as claimed in <sup>claim 7</sup> ~~any of claims 7 to 9~~, characterised by said step of enabling all carrier waves including, on a continuous basis, in said first transceiver:

- said transmitter obtaining data relating to measured channels from receivers in both said transceivers;
- said transmitter determining the bit loading parameter for each carrier wave;

- said transmitter transmitting data relating to the bit loading parameter to said second transceiver;
- said transmitter changing the bit loading parameter on confirmation from said second transceiver;
- the receiver measuring the channel characteristics of said multiplicity of channels and sending data relating to said measurements to said transmitter;
- the receiver equalizing said multiplicity of channels in accordance with said measured channel characteristics;
- the receiver obtaining a channel estimation from said second transceiver for each of said multiplicity of channels;
- the receiver obtaining a new bit loading parameter for each of said multiplicity of channels;
- the receiver obtaining a confirmation signal from said second transceiver;
- the receiver updating the bit loading parameters for each of the multiplicity of channels.

*Claim 17*

27. A method, as claimed in ~~any of claims 17 to 26,~~ characterised by estimating channel characteristics by periodic transmission, by one of said transceivers, of a base sync frame having a predetermined content and comparing, in the other of said transceivers, the

received sync frame with a reference frame.

28. A method, as claimed in claim 27, characterised by said channel characteristics including attenuation, phase shifting and variance.

5 *a* 29. A method, as claimed in either claim 27, ~~or 28~~, characterised by transmitting said base sync frames at intervals, the BSI, and locking said BSI into said transceivers thereby enabling said transceivers to identify a frame as a sync frame.

0 30. A method, as claimed in claim 29, characterised by transmitting additional sync frames at intervals between said base sync frames.

15 *a* 31. A method, as claimed in <sup>claim 29</sup> ~~either claims 29, or 30~~, characterised by said first transceiver issuing commands for system reconfiguration at the start of a BSI and effecting system reconfiguration at the start of the next BSI.

20 *a* 32. A method, as claimed in <sup>claim 29</sup> ~~any of claims 29 to 31~~, characterised in that said BSI is greater than twice the system transit time for signals.

25 *a* 33. A receiver, characterised in that it is adapted for use with a multi-carrier transmission system as claimed <sup>in claim 1</sup> ~~in any of claims 1 to 17, or adapted to implement the method claimed in any of claims 17 to 32.~~

30 *a* 34. A transmitter, characterised in that it is adapted for use with a multi-carrier transmission system as claimed in <sup>claim 1</sup> ~~any of claims 1 to 17, or adapted to implement the method claimed in any of claims 17 to 32.~~

35. A transceiver, characterised in that it includes a

receiver as claimed in claim 33 ~~and a transmitter as~~  
~~claimed in claim 34.~~

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